Procedure for th manufacture of a foam d plastic product

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Abstract

PCT No. PCT/FI95/00433 Sec. 371 Date Apr. 21, 1997 Sec. 102(e) Date Apr. 21, 1997 PCT Filed Aug. 16, 1995 PCT Pub. No. WO96/06718 PCT Pub. Date Mar. 7, 1996A process for fabricating a foamed plastic product. The process includes a plastic film that is prefoamed in order to introduce lamellar discontinuities such as prefoamed bubbles. The film is pressurized by a gas under a positive pressure causing the gas to diffuse into the film, forming a second film. Further, the second film is inflated in order to form the foamed plastic product. The second film is inflated by heating the second film at a temperature below the melting point of the second film and under a reduced pressure.

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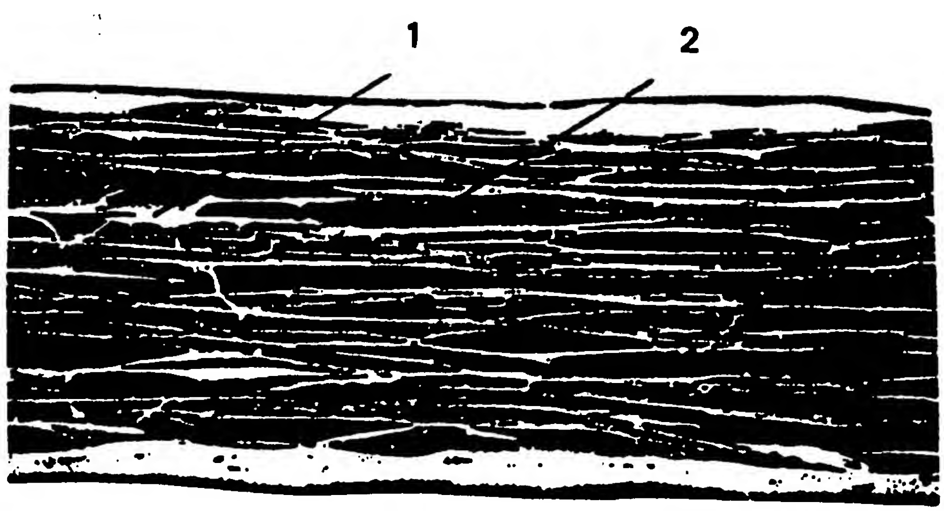
(54) Title: PROCEDURE FOR THE MANUFACTURE OF A FOAMED PLASTIC PRODUCT



(57) Abstract

Procedure for the manufacture of a foamed plastic product, in which procedure a filmlike plastic product (1) is perfoamed e.g. by using foaming agents added into the manufacturing process, in such a way that lamellar discontinuities (2), e.g. prefoamed bubbles, are created in the product (1). The product (1) is pressurized with a desired gas, such as nitrogen or air, under positive pressure, causing the gas to diffuse into the product. The product (1) is then inflated by sujecting it to a heat treatment under reduced pressure during which the product is heated at a temperature below its melting point.

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PROCEDURE FOR THE MANUFACTURE OF A FOAMED PLASTIC PRODUCT

The present invention relates to a procedure for the manufacture of a foamed plastic product as defined in claim 1.

Foamed plastic films and blanks can be manufactured primarily by using foaming agents added directly into the film production process or by orientation stretching at a suitable temperature of a film structure containing special additives. With normal extrusion foaming methods, foaming degrees exceeding 50% are seldom achieved.

E.g. US patent 4 473 665 presents methods for pressurizing solid plastic with gas to achieve foaming. However, these methods require pressures of several tens, even hundreds of MPa.

The object of the present invention is to produce a procedure for pressure inflation of a prefoamed plastic film that makes it possible to manufacture strongly foamed film products, involving a high foaming degree and allowing the thickness of the product to be increased without increasing the amount of plastic material.

In the procedure of the invention, a polymer to be inflated contains a structural boundary layer or micropore in which a bubble is nucleated and which is inflated during a pressurizing processs. The details of the features characteristic of the procedure of the invention are presented in the attached claims.

Films inflated by the pressurizing method are visually more dull and have an increased opacity and untransparency as compared with uninflated products. In practice, the change in the visual characteristics of the film improves its properties relating to printability. The films have more pap r-like rigidity characteristics, and the product is more elas-

tic and has a better (thermal, optical) insulating capability than an uninflated film.

By the pressurizing method, using biaxially oriented polypropylene films prefoamed to 30%, it is possible to produce homogeneous foamed films and sheets with an 80-% foaming degree. Since the inflation of the foam bubbles occurs at a temperature lower than the melting point of the polymer, the bubble walls of the structure are oriented simultaneously. The orientation increases the structural strength of the final product.

The pressure required in the procedure of the invention is of the order of only 1 MPa and accordingly the pressurization chambers needed are structurally light, thus making the procedure economical.

In the following, the invention is described in detail by the aid of an example by referring to the attached drawing, in which

Fig. 1 presents an uninflated film (prefabricated product), Fig. 2a - 2 c illustrate the manufacture of foamed plastic films by the method of the invention and Fig. 3 presents an inflated film.

The basic film/blank 1 presented by Fig. 1 contains discontinuities 2 which may consist of prefoamed bubbles or boundary layers/spaces (boundary layer in a lamellar structure) formed by solid particles where a gas can be diffused and stored.

The basic film/blank 1 may have a thickness of the order of D = 5 µm - 1000 µm. The basic film/blank 1 may be in an unoriented state or in a biaxially oriented state. In this context, orientation refers to a method of processing of the plastic film/blank whereby the product is melted and then precooled to a temperature below the crystallization point

and heated again to the orientation temperature for the time required by the stretching. The orientation temperature is lower than the melting point of the polymer.

The foamed structure in the basic film/blank 1 may be a lenslike structure produced by adding foaming agents into the process. It may also be a "shredded" or cavitated foamed structure resulting from internal shredding of the structure during orientation stretching, caused by solid additives or particles added into the polymer.

Fig. 2 presents an apparatus comprising an unwinding roller 3 and an end roller 4 for a film web 1, placed in a chamber 5. On the unwinding roller's side of the chamber 5 (on the right in Fig. 2a) there is also a guide roller 6 and after that two rollers 7,8 placed one upon the other, the upper one 7 of these rollers being movable in the vertical direction (as indicated by the vertical double-headed arrow) by means of a drive mechanism in such a way that, when roller 7 is in its low position, the gap between the rollers 7,8 forms a nip 9 as shown in Fig. 2a. The film has a thickness of D.

During gas treatment A as illustrated by Fig. 2a, the upper roller 7 is in its high position, leaving a large gap between the two rollers 7,8 placed one over the other. The foamed film/blank 1 is placed in the chamber 5, which can be pressurized. For pressurization, nitrogen, air or other gas can be used. In the chamber 5, the films 1 can be handled as a weblike product, the product 1 being wound from the unwinding roller 3 to the end roller so that it runs from the unwinding roller 3 obliquely upwards to an upper guide roller 10 placed at a higher level and further to guide roller 6. From here, the film 1 is passed around the upper roller 7 onto the lower roller 8, after which the film runs obliquely downwards to a lower guide roller 11 below and further to the end roller 4 as indicated by the arrows in Fig. 2b.

In the pressurized space 5, the internal boundary layers in the film/blank 1 are filled with gas. The amount of gas diffused into the film 1 and the rate of diffusion can be increased by heating the film 1 inside the chamber 5, lowering the rolling speed, increasing the pressure or by increasing the free-run distance travelled by the film 1 by passing it over auxiliary rollers. Auxiliary rollers and heating also improve the homogeneity of the diffusion process. Cooling the film 1 before its wound onto the end roller retards the diffusion of the gas from the film material 1.

After the winding in the chamber 5 under positive pressure, the chamber is depressurized and the finished roll is inflated (B, Fig. 2c). It is subjected to a new heat treatment, during which it is heated over the distance between the unwinding and end rollers. In Fig. 2c, the film is wound in the opposite direction as compared with Fig. 2b, as indicated by the arrows. The heating of the film 1 can be effected by using radiated heat or, to achieve a better thickness control of the end product, in the nip 9 between two heat rollers 7,8. The heat treatment performed after the film has been wound under positive pressure results in a permanent inflation of the product. The film 1 can also be inflated temporarily without heating, but such inflation will not be permanent because, due to the elastic properties of the polymer, the product is flattened to its original state after the gas has diffused away from the structure. Inflation effected between heating rollers 7,8 results in a very uniform thickness profile of the film/blank 1.

The thickness and the degree of inflation of the final product and can be adjusted by adjusting the nip distance and the distance travelled by the film on the heating rollers 7, 8. The inflation is performed at a temperature below the melting point of the polymer.

To reduce the costs, the same equipment can be used to wind the film under positive pressure and to wind it for infla-

tion. The inflation efficiency can be further enhanced by creating a negative pressure in the chamber 5.

Fig. 3 illustrates a final product 1 as provided by the invention, in which the lamellar boundary layers 2 have been inflated to form lamellar gas gaps, making the product extremely elastic in its thicknesswise direction.

It is obvious to a person skilled in the art that different embodiments of the invention are not restricted to the example described above, but that they may instead be varied within the scope of the following claims.

CLAIMS

1. Procedure for the manufacture of a foamed filmlike plastic product,

in which the product (1) is pressurized (A) with a desired gas, such as nitrogen or air, under a positive pressure, causing the gas to diffuse into the product (1), and

in which the product (1) is then inflated (B) by subjecting it to a heat treatment during which the product is heated at a temperature below its melting point and under a reduced pressure,

characterized in that

the filmlike plastic product (1) to be inflated contains lamellar structural boundary layers.

2. Procedure as defined in claim 1, **characterized** in that the plastic product (1) to be inflated has been biaxially oriented.

3. Procedure as defined in claim 1, **characterized** in that the plastic product (1) to be inflated has been prefoamed.

4. Procedure as defined in claim 1, **characterized** in that the product (1) is wound under positive pressure from one roller (3) to another (4), and that the inflation of the product (1) is performed by means of heatable rollers (7,8) while the product is being wound in the opposite direction.

5. Procedure as defined in claim 1, **characterized** in that the plastic product (1) is prefoamed e.g. by using foaming agents or solid particles added into the manufacturing proc ss, in such a way that lamellar discontinuities (2) are created in the product (1), said discontinuities consisting .g. of prefoamed bubbles or gaps resulting from shredding.

6. Procedure as defined in claim 1, in which the heat treatment is implemented as radiation heating or in the nip (9) between two heating rollers (7,8), **characterized** in that the thickness and the degree of inflation of the final product and can be adjusted by adjusting the nip distance and the distance travelled by the film on the heating rollers (7,8).

7. Procedure as defined in claim 1, **characterized** in that the product (1) is subjected to negative pressure during the heat treatment.

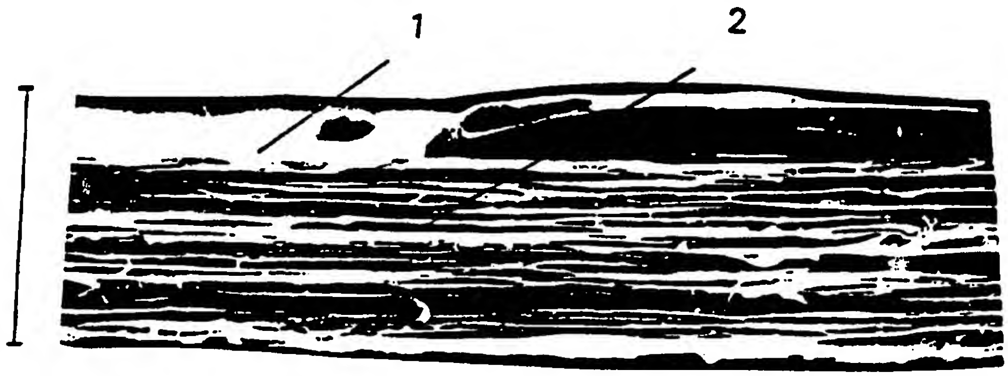


FIG. 1

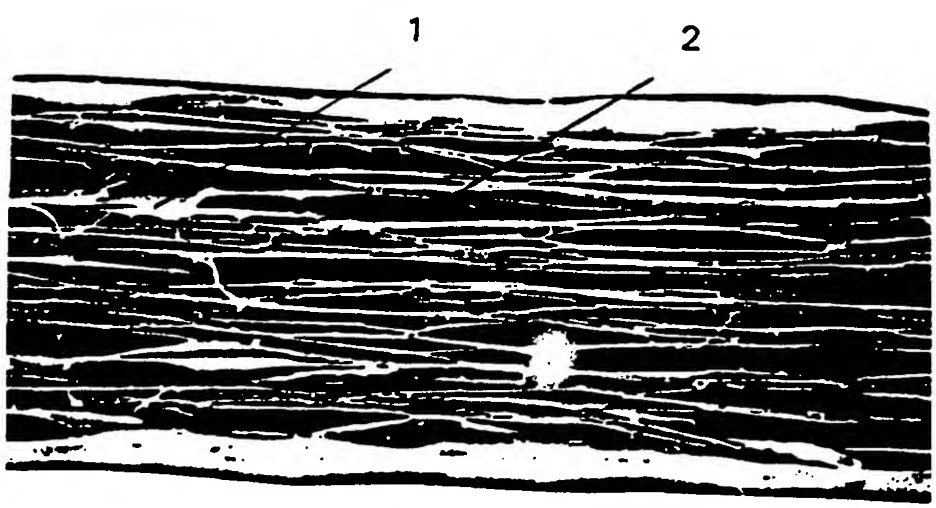


FIG. 3

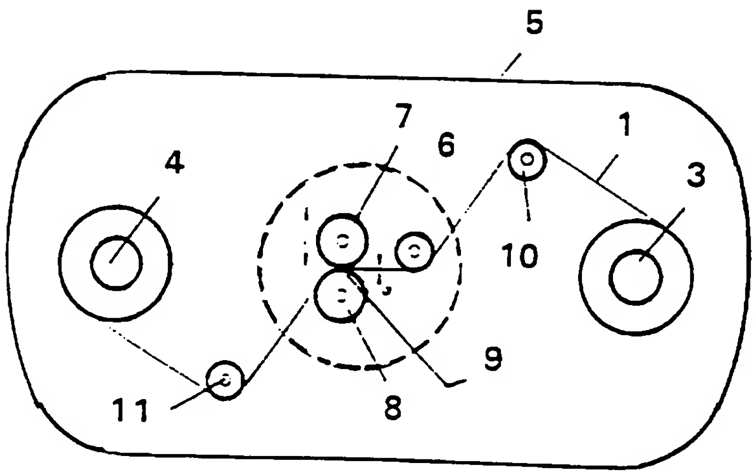
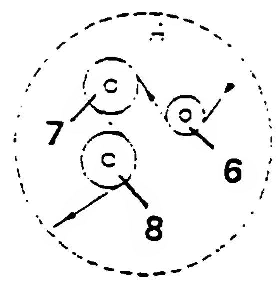


FIG. 2a

FIG. 2b



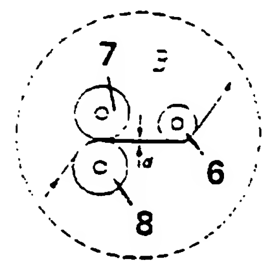


FIG. 2c

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 95/00433

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: B29C 44/20 // C08J 9/12
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B29C, B29D, C08J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 8805379 A1 (EASTMAN KODAK COMPANY), 28 July 1988 (28.07.88), page 1, line 1 - line 13; page 9, line 13 - line 20; page 36, line 15 - line 25, figures 1,5, claims 1,5-6, abstract	1,6-7
Y		3,5
A	abstract	4
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Y	WO 9416876 A1 (THE DOW CHEMICAL COMPANY), 4 August 1994 (04.08.94), page 10, line 6 - line 16, claims 1,3-4	3,5
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
11 December 1995	15.12.95.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4473665 A (JANE E. MARTINI-VVEDENSKY ET AL), 25 Sept 1984 (25.09.84) --	1-7
A	WO 9217533 A1 (MASSACHUSETTS INSTITUTE OF TECHNOLOGY), 15 October 1992 (15.10.92), claim 6, abstract -- --------	1-7

INTERNATIONAL SEARCH REPORT

Information on patent family members

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International application No.

PCT/FI 95/00433

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WO-A1-	8805379	28/07/88	US-A-	4761256	02/08/88
WO-A1-	9416876	04/08/94	NONE		
US-A-	4473665	25/09/84	NONE		
WO-A1-	9217533	15/10/92	CA-A-	2107355	06/10/92
			EP-A,A-	0580777	02/02/94
			JP-T-	6506724	28/07/94
			US-A-	5158986	27/10/92
			US-A-	5334356	02/08/94